Discussion of SJGS Coal Ranking for BART NO_x Presumptive Limit Determination

Summary of NMED/US EPA review:

In an e-mail transmittal on March 20, 2008 from the New Mexico Environment Department (NMED) PNM received an evaluation by US EPA of the San Juan coal that is combusted at the San Juan Generating Station (SJGS) units. The e-mail transmittal is attached as ***Appendix A***. The evaluation was performed by the US EPA and was based on the ASTM D388 classification method (attached as ***Appendix B***) to determine the coal ranking. Average coal analysis values referenced from the B&W Low NO_x Burner/Overfire Air (LNB/OFA) contract were used in this evaluation (attached as ***Appendix C***).

In the evaluation, EPA concedes that based on the average coal analysis, the coal classification falls into a gray area between subbituminous and bituminous. However, EPA is concerned that since the coal analysis is an average value, if the heating value of the coal is the lower half of the range, this would rank the coal as subbituminous. The EPA concludes that subbituminous rank should be assigned to the San Juan coal based on the following coal characteristics:

1. Heating value = 9,502 Btu/lb (especially concerned with the lower range of heating value since this is an average value).
2. Chlorine content = 0.03% is lower than typical bituminous coal (expected at 0.1%).
3. Volatile matter = 33.76% is higher than typical bituminous coal (expected at 16%).

Response:

PNM agrees that the coal burned at SJGS falls into a gray area between subbituminous coal and bituminous coal. The main objective in investigating the ranking of the coal combusted at SJGS is to determine the applicable BART NO_x presumptive emission limit. With respect to NO_x combustion control performance, SJGS coal behaves more like a bituminous coal as the following discussion will illustrate.

New, state-of-the-art combustion controls are being retrofitted as a result of the consent decree upgrades. The LNB, OFA, and Neural Network (NN) being installed on each of the SJGS units are equivalent to the BART technology used to develop the 0.39 lb/MBtu presumptive NO_x limit for units combusting bituminous coal, or 0.23 lb/MBtu for units combusting PRB subbituminous coal in the BART Rule.

NMED EX. 7m

The ASTM D388 classification method referenced by the EPA classifies coal based on the range of heating value (in Btu/lb) and the volatile matter content. The ASTM D388 method is based on the moist, mineral-matter free basis. The EPA compared the "as received" heating value of 9,502 Btu/lb to the classification table in ASTM D388. This is not a valid comparison because the "as received" heating value must be converted to a "moist, mineral-matter free" heating value. The Parr Formulas is used to convert the as-received heating value of 9,502 Btu/lb (as received) referenced by the EPA to a value of 12,443 Btu/lb (moist, mineral-matter-free), and is as follows:

Moist, mineral-free Btu = (Btu – 50S) / {100 – (1.08A + 0.55S)} x 100, per lb

where,

Btu = heating value per lb (as received)

A = ash, %

S = sulfur, %

With the conversion of the San Juan coal heating value to the correct basis for classification using ASTM D388, the average coal heating value falls into the high volatile C bituminous rank. The San Juan coal does not fall into the subbituminous rank of ASTM D388.

The EPA also indicates that a coal classification determined based on the average coal heating value will potentially neglect subbituminous ranked coal that may be combusted. In response to this comment, a detailed evaluation of the individual coal samples from the supply mine was made. The individual coal sampling period evaluated was from April 1, 2003 through February 29, 2008, which represented a total of 11,655 individual delivery samples. Statistical analysis performed on these individual samples was made to group the data from each individual sample into the following:

1. Overall total and average
2. Daily average maximum
3. Daily average minimum
4. Single sample maximum
5. Single sample minimum

The results of this analysis are shown below:

Daily Coal Sample Averages for April 2003 through February 2008

Tons	Ave. %Moist.	Ave. %Ash	Ave. Btu/Lb.	Ave. % Sulfur	Parr # 3	Ave. PSO2	Overall total & averages
32,286,576	9.58	20.57	9,670	0.73	12,449	1.51	Overall total & averages

Tons	Ave. %Moist.	Ave. %Ash	Ave. Btu/Lb.	Ave. % Sulfur	Parr # 3	Ave. PSO2	Daily averages max. and min.
69,272	10.91	25.56	10,170	0.88	12,866	1.86	Daily averages maximums
966	7.64	17.65	9,132	0.52	12,131	1.04	Daily averages minimums

Tons	%Moist.	%Ash	Btu/Lb.	% Sulfur	Parr # 3	PSO2	Single sample max. and min.
4,710	12.99	31.99	10,415	1.07	13,098	2.19	Single sample maximums
454	6.83	16.50	7,994	0.50	11,811	0.99	Single sample minimums

In order to compare the results to ASTM D388, the "as received" heating value was converted to "moist, mineral-free" heating value (using Parr #3 formula). These results are provided above under the column labeled "Parr #3". The results indicate that no samples from the all-underground supply period (from April 1, 2003 through February 29, 2008) would be classified as subbituminous. The lowest coal heating value from the single sample minimum is 11,811 (moist, mineral-matter-free). In the ASTM D388 classification, the high volatile C bituminous rank ranges from 11,500 to 13,000 Btu/lb (moist, mineral-matter-free). Therefore, essentially all the coal burned at SJGS would be considered bituminous coal according to ASTM D388.

The second classification criteria that the EPA used was the average volatile matter content which for SJGS is 33.76% (as received). The SJGS value was compared with the properties of coal found in B&W's Steam book (41st Ed., Chapter 9, Table 5, attached as ***Appendix D***) for various US coals. EPA stated that the bituminous coals can have volatile matter content as low as 16%. It should also be noted, however, that in the same table, the range of volatile matter content for bituminous ranked coal ranges from 16% to 40%. Therefore, the relatively high volatile matter content of the San Juan coals at 33.76% is within the range of expected content level for bituminous coals. In fact, it is higher than all the subbituminous coals listed in Table 5 and fits much better in the range of coals listed as bituminous.

The chlorine content of the San Juan coals at 0.03% was also referenced by the EPA as differentiator in determining the coal ranking. While, it is true that the chlorine content is lower for the San Juan coals than other bituminous coals (EPA expected value of 0.1%), the chlorine content in coal does not impact the NO_x emission level. Therefore, chlorine content is irrelevant for the determination of the presumptive NO_x limit.

In the PNM SJGS BART submittal to NMED in June 2007, Section 4.1.4 of the report (attached as ***Appendix E***) discusses reasons why NO_x emissions levels achieved using combustion controls at SJGS should not be compared to a PRB subbituminous coal for the purposes of establishing a NO_x presumptive limit. The reasons provided are briefly recapped below:

1. <u>Oxygen content < subbituminous:</u> SJGS coal oxygen content at 9.38%, is lower than bituminous coal (10.09%) and substantially lower than subbituminous coal (11.68%). Oxygen content in coal impacts NO_x emissions because higher fuel oxygen content reduces the amount of additional air (i.e., nitrogen) required for combustion, reducing amount of nitrogen for formation of NO_x.
2. <u>Moisture content < subbituminous:</u> SJGS coal moisture content at 8.72%, is lower than bituminous coal (9.40%) and substantially lower than subbituminous coal (29.95%). Moisture content in coal impacts NO_x emissions because higher fuel moisture content reduces the flame temperature and, therefore, reduces the formation of thermal NO_x.
3. <u>Nitrogen content > subbituminous:</u> SJGS coal nitrogen content at 1.08%, is higher than subbituminous coal (0.63%). Nitrogen content in coal impacts NO_x emissions because of the oxidation of fuel-bound nitrogen to form NO_x.
4. <u>SJGS boiler design (smaller effective boiler volume):</u> the SJGS effective boiler volume is smaller when compared to boilers designed to combust PRB coal with similar steam output capacity. The smaller volume boiler will operate hotter, thus increasing thermal NO_x formation.

This fundamental understanding of the variation in NO_x formation from different types of US coals and the inherent SJGS boiler design characteristics explains why the expected NO_x rates of boilers burning the coal fired at SJGS cannot be as low as boilers firing PRB subbituminous coals.

Conclusion:

The discussions included here on the San Juan coal heating value, coal volatile matter content, coal combustion characteristics, and SJGS boiler design provide a strong basis for why the BART NO_x presumptive limit for SJGS should not be based on the combustion of subbituminous coal. The proposed consent decree NO_x control level of 0.30 lb/MBtu is appropriately in between the BART NO_x presumptive limit for subbituminous coal (at 0.23 lb/MBtu) and bituminous coal (at 0.39 lb/MBtu). In effect, the 0.30 lb/MBtu is equivalent (for SJGS) to the presumptive limit for PRB or eastern bituminous fuels.

APPENDIX A
NMED/EPA REVIEW OF COAL CLASSIFICATION

Chang, Daniel

From: Norem, Nancy [Nancy.Norem@pnmresources.com]
Sent: Wednesday, April 30, 2008 5:10 PM
To: Fischer, Diane M.; Huggins, Roosevelt; Lucas, Kyle J.; Chang, Daniel
Subject: FW: PNM - NOx Information Review

I am forwarding you a string of emails that the NMED sent me regarding SJ coal classification.

From: Trujillo, Rita, NMENV [mailto:rita.trujillo@state.nm.us]
Sent: Thursday, March 20, 2008 4:38 PM
To: Norem, Nancy
Cc: Uhl, Mary, NMENV; Kuehn, Elizabeth, NMENV
Subject: FW: PNM - NOx Information Review

Hi Nancy -

I'm forwarding to you an e-mail from Sikander Khan from EPA regarding the classification of the San Juan coal as sub-bituminous. Based on our conversation with and this e-mail from Sikander, we believe that the coal burned in the San Juan Generating Station should be classified as sub-bituminous.

Rita

From: Kuehn, Elizabeth, NMENV
Sent: Friday, March 14, 2008 3:06 PM
To: Uhl, Mary, NMENV; Trujillo, Rita, NMENV; Schooley, Ted, NMENV; Mustafa, Sufi A., NMENV; Kim, Gi-Dong, NMENV
Subject: RE: PNM - NOx Information Review

All-
Below is a summary of our discussion with Sikander Khan at EPA regarding the coal classification at the SJGS.

Thanks,
Liz

From: Khan.Sikander@epamail.epa.gov [mailto:Khan.Sikander@epamail.epa.gov]
Sent: Wed 2/27/2008 2:42 PM
To: Kuehn, Elizabeth, NMENV
Subject: RE: PNM - NOx Information Review

Liz,

Here is a summary of what we discussed today:

ASTM D 388 sets the guidelines for classifying coals and, especially for lignite, sub-bituminous and high-volatile bituminous coals, such classification is based on the higher heating value. For other coals, fixed carbon and volatile contents determine the exact class of these coals.

PNM does not provide sufficient information with their coal analysis to enable us to determine the exact classification of their coal. They have provided only the average coal analysis. What we need is a range of analyses as well as information on surface moisture and ash mineral contents. With the given information, the coal appears to fall in a gray area, where it can be classified as either sub-bituminous or high-volatile bituminous coal. However, since the analysis provided by PNM is for the average coal, it appears that some samples of this coal with heating values below the average may fall squarely in the sub-bituminous column. Please note that, if the analysis provided by PNM is average, chances are that half of the samples of this coal would have heating values below the 9,502 Btu/lb listed as an average.

The chlorine content and volatile matter of the average coal appear to be a lot like what would be expected of sub-bituminous coals. The chlorine content at 0.03% is too low (I would expect bituminous coal chlorine to be generally higher than 0.1%). The average volatile matter at 33.76% is fairly high and is more typical of sub-bituminous coals. PNM also states that the minimum volatile matter would be 48% on a dry, ash free basis, which is also very high and is representative of a sub-bituminous coal. All of these numbers are based on information provided in the contract PNM recently signed with B&W for the supply of combustion controls. For examples of analyses of US coals, you can refer to B&W's Steam book (41st Edition, Chapter 9, Table 5). This table shows that the volatile content of eastern bituminous coals can be as low as close to 16%. The sub-bituminous coals would have volatile contents always exceeding 30%. Given the low chlorine content, relatively low heating value, and relatively high volatile content, the PNM coal can be classified as sub-bituminous.

It is easier to combust a coal with a higher volatile content in a boiler. This ease of burning for sub-bituminous coals is known to improve efficiency of combustion controls employed to reduce NOx. With the high volatile coal content, PNM can be expected to achieve good performance from their new combustion controls. You can see the projected differences in NOx reduction for bituminous and sub-bituminous coals with combustion controls on the EPA website, http://www.epa.gov/airmarkets/progsregs/epa-ipm/. Please scroll down to the bottom area of this web page, under the Section, Documentation for EPA Base Case 2006 (v3.0). Click on Section 3 and go to Table A 3-1:3. The last two columns of this table show the NOx reduction efficiencies that can be achieved with different types of combustion controls on bituminous and sub-bituminous coals. The difference in the efficiencies in more pronounced if you use the formulae in the second-last column. Here you can assume a baseline NOx rate (for example 0.5 lb/MMBtu) without controls for the two coals and then apply the formulae to see that the NOx reduction efficiency for subbituminous coal is better than what you can achieve with bituminous coal, with the same NOx controls. The last column is the default efficiency that is still better for the sub-bituminous coals. The main factor behind these projections is the coal volatile content.

In one of your previous emails, you had referred to documents where PNM and B&W had defined the above coal to fall under sub-bituminous category. I believe that those documents provide another solid proof that this coal should be considered sub-bituminous type.

The contact at our North Carolina office that I mentioned goes by the name Ravi Srivastava and his phone number is 919-541-3444.

I hope that the above is of some help to you in resolving the issues with PNM. Good luck.

Sikander Khan
US EPA

Telephone: 202-343-9781
Fax: 202-343-2356
Email Address: khan.sikander@epa.gov

APPENDIX B
ASTM D388 GUIDELINE

Table 3
Classification of Coals by Rank[a] (ASTM D 388)

Class	Group	Fixed Carbon Limits, % (Dry, Mineral-Matter-Free Basis) Equal or Greater Than	Fixed Carbon Limits, % Less Than	Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis) Greater Than	Volatile Matter Limits, % Equal or Less Than	Calorific Value Limits, Btu/lb (Moist,[b] Mineral-Matter-Free Basis) Equal or Greater Than	Calorific Value Limits, Btu/lb Less Than	Agglomerating Character
I. Anthracitic	1. Meta-anthracite	98	—	—	2	—	—	Nonagglomerating
	2. Anthracite	92	98	2	8	—	—	
	3. Semianthracite[c]	86	92	8	14	—	—	
II. Bituminous	1. Low volatile bituminous coal	78	86	14	22	—	—	Commonly agglomerating[e]
	2. Medium volatile bituminous coal	69	78	22	31	—	—	
	3. High volatile A bituminous coal	—	69	31	—	14,000[d]	—	
	4. High volatile B bituminous coal	—	—	—	—	13,000[d]	14,000	
	5. High volatile C bituminous coal	—	—	—	—	11,500	13,000	
						10,500[e]	11,500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	—	—	—	—	10,500	11,500	Nonagglomerating
	2. Subbituminous B coal	—	—	—	—	9,500	10,500	
	3. Subbituminous C coal	—	—	—	—	8,300	9,500	
IV. Lignitic	1. Lignite A	—	—	—	—	6,300	8,300	
	2. Lignite B	—	—	—	—	—	6,300	

[a]This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high volatile bituminous and subbituminous ranks. All of these coals either contain less than 48% dry, mineral-matter-free Btu/lb.

[b]Moist refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

[c]If agglomerating, classify in low volatile group of the bituminous class.

[d]Coals having 69% or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

[e]It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high volatile C bituminous group.

$$\text{Dry, mineral–free } VM = 100 - \text{Dry, mineral–free } FC, \% \qquad (2)$$

$$\text{Moist, mineral–free Btu} = \frac{\text{Btu} - 50\,\text{S}}{100-(1.08A+0.55\,\text{S})} \times 100, \text{ per lb} \qquad (3)$$

Table 4
Coal Analyses on As-Received Basis
(Pittsburgh Seam Coal, West Virginia)

Proximate Analysis Component	% by wt	Ultimate Analysis Component	% by wt
Moisture	2.5	Moisture	2.5
Volatile matter	37.6	Carbon	75.0
Fixed carbon	52.9	Hydrogen	5.0
Ash	7.0	Sulfur	2.3
Total	100.0	Nitrogen	1.5
		Oxygen	6.7
Heating value,		Ash	7.0
Btu/lb	13,000	Total	100.0
(kJ/kg)	(30,238)		

Approximation Formulas

$$\text{Dry, mineral–free } FC = \frac{FC}{100-(M+1.1A+0.1\,\text{S})} \times 100, \% \qquad (4)$$

$$\text{Dry, mineral–free } VM = 100 - \text{Dry, mineral–free } FC, \% \qquad (5)$$

$$\text{Moist, mineral–free Btu} = \frac{\text{Btu}}{100-(1.1A+0.1\,\text{S})} \times 100, \text{ per lb} \qquad (6)$$

where

Btu = heating value per lb (kJ/kg = 2.326 × Btu/lb)
FC = fixed carbon, %
VM = volatile matter, %
M = bed moisture, %
A = ash, %
S = sulfur, %

all for coal on a moist basis.

Table 5 lists 17 selected U.S. coals, arranged in order of ASTM classification. The following descriptions briefly summarize the characteristics of each coal rank.

APPENDIX C
B&W LNB/OFA FUEL DESIGN CRITERIA

San Juan Generating Station
Unit 3 and Unit 4

EXHIBIT A PERFORMANCE GUARANTEES

Table 1.2.1 – Burner Design/Guarantee Basis

Description	Units	Design Basis
Total Heat Input from Fuel	MBtu/hr	5485
Excess Air (Leaving Economizer)	%	20
Number of pulverizers in service (1)	#	5 or 6
Number burners in service	#	35 or 42
Primary Air to Coal Flow Ratio	Lb-air/lb-coal	1.95
Air Temperature Leaving Air Heater	Deg F	579
Feedwater Temperature	Deg F	479
Furnace Pressure	Inches w.g.	9.9
Windbox Pressure	" H2O	17.4
Pulverizer Outlet Temperature	Deg F	150
Overfire Air Flow	Mlb/hr	1,213

Note (1): BWC reserves the right to select which mill is out of service.

Table 1.2.2: Design/Guarantee Basis Fuel Criteria (1)

Fuel Type: →	Design Coal
Proximate Analysis:	%wt. (as-fired)
Moisture	8.93
Ash	21.78
Volatile Matter (VM)	33.76
Fixed Carbon (FC)	35.53
Total	100.00
HHV (Btu/lb)	9,502
Ultimate Analysis:	%wt. (as-fired)
Moisture	8.93
Ash	21.78
Carbon	54.21
Hydrogen	4.04

San Juan Generating Station
Unit 3 and Unit 4

EXHIBIT A PERFORMANCE GUARANTEES

Sulfur	0.76
Nitrogen	1.00
Oxygen	9.28
Chlorine	0.03
Total	100.0
Fuel Limits:	
% Volatile Matter (%wt. dry, ash free)	≥ 48.0
% Oxygen (%wt. dry, ash free)	≥ 13.0

(1) Fuel samples shall be collected during the testing to confirm compliance with these criteria. The fuel analyses shall be performed in accordance with ASTM standard procedures.

Table 1.2.3 – Flue Gas Analysis Entering Baghouse

ITEM	UNIT 3&4 PERFORMANCE CONDITION DESIGN COAL	
Fuel	Design coal	Mass %
Boiler Heat Input, MBtu/hr	5485.2	
Flue Gas, lb/hr		
CO_2	1,146,630	18.70
H_2O	324,454	5.29
N_2	4,268,137	69.60
O_2	320,453	5.23
SO_2	8,600	0.14
HCl	210	0.003
SO_3	79	0.00
Ash, lb/hr + PAC lb/hr	63,464	1.035
Flue gas flow rate, lb/hr (w/solids)	6,132,027	100%

APPENDIX D
US COAL PROPERTIES
(B&W STEAM, 41ST EDITION, CHAPTER 9, TABLE 5)

Table 5
Seventeen Selected U.S. Coals Arranged in Order of ASTM Classification

No.	Coal Rank Class	Coal Rank Group	State	County	M	VM	FC	A	S	Btu	Rank FC	Rank Btu
					Coal Analysis, Bed Moisture Basis							
1	I	1	Pa.	Schuylkill	4.5	1.7	84.1	9.7	0.77	12,745	99.2	14,280
2	I	2	Pa.	Lackawanna	2.5	6.2	79.4	11.9	0.60	12,925	94.1	14,880
3	I	3	Va.	Montgomery	2.0	10.6	67.2	20.2	0.62	11,925	88.7	15,340
4	II	1	W.Va.	McDowell	1.0	16.6	77.3	5.1	0.74	14,715	82.8	15,600
5	II	1	Pa.	Cambria	1.3	17.5	70.9	10.3	1.68	13,800	81.3	15,595
6	II	2	Pa.	Somerset	1.5	20.8	67.5	10.2	1.68	13,720	77.5	15,485
7	II	2	Pa.	Indiana	1.5	23.4	64.9	10.2	2.20	13,800	74.5	15,580
8	II	3	Pa.	Westmoreland	1.5	30.7	56.6	11.2	1.82	13,325	65.8	15,230
9	II	3	Ky.	Pike	2.5	36.7	57.5	3.3	0.70	14,480	61.3	15,040
10	II	3	Ohio	Belmont	3.6	40.0	47.3	9.1	4.00	12,850	55.4	14,380
11	II	4	Ill.	Williamson	5.8	36.2	46.3	11.7	2.70	11,910	57.3	13,710
12	II	4	Utah	Emery	5.2	38.2	50.2	6.4	0.90	12,600	57.3	13,560
13	II	5	Ill.	Vermilion	12.2	38.8	40.0	9.0	3.20	11,340	51.8	12,630
14	III	1	Mont.	Musselshell	14.1	32.2	46.7	7.0	0.43	11,140	59.0	12,075
15	III	2	Wyo.	Sheridan	25.0	30.5	40.8	3.7	0.30	9,345	57.5	9,745
16	III	3	Wyo.	Campbell	31.0	31.4	32.8	4.8	0.55	8,320	51.5	8,790
17	IV	1	N.D.	Mercer	37.0	26.6	32.2	4.2	0.40	7,255	55.2	7,610

Notes: For definition of Rank Classification according to ASTM requirements, see Table 3.

Data on Coal (Bed Moisture Basis)

M = equilibrium moisture, %; VM = volatile matter, %;
FC = fixed carbon, %; A = ash, %; S = sulfur, %;
Btu = Btu/lb, high heating value.

Rank FC = dry, mineral-matter-free fixed carbon, %;
Rank Btu = moist, mineral-matter-free Btu/lb.
Calculations by Parr formulas.

Peat Peat, the first product in the formation of coal, is a heterogeneous material consisting of partially decomposed plant and mineral matter. Its color ranges from yellow to brownish black, depending on its geologic age. Peat has a moisture content up to 70% and a heating value as low as 3000 Btu/lb (6978 kJ/kg).

Lignite Lignite is the lowest rank coal. Lignites are relatively soft and brown to black in color with heating values of less than 8300 Btu/lb (19,306 kJ/kg). The deposits are geologically young and can contain recognizable remains of plant debris. The moisture content of lignites is as high as 30% but the volatile content is also high; consequently, they ignite easily. Lignite coal dries when exposed to air and spontaneous combustion during storage is a concern. Long distance shipment of these coals is usually not economical because of their high moisture and low Btu contents. The largest lignite deposit in the world spreads over the regions of North and South Dakota, Wyoming, and Montana in the U.S. and parts of Saskatchewan and Manitoba in Canada.

Subbituminous Subbituminous coals are black, having little of the plant like texture and none of the brown color associated with the lower rank lignite coal. Subbituminous coals are noncoking (undergo little swelling upon heating) and have a relatively high moisture content which averages from 15 to 30%. They also display a tendency toward spontaneous combustion when drying.

Although they are high in volatile matter content and ignite easily, subbituminous coals generally have less ash and are cleaner burning than lignite coals. Subbituminous coals in the U.S. in general have a very low sulfur content, often less than 1%. Because they have reasonably high heating values [8300 to 11,500 Btu/lb (19,306 to 26,749 kJ/kg)] and low sulfur content, switching to subbituminous coal has become an attractive option for many power plants to limit SO_2 emission.

Bituminous Bituminous coal is the rank most commonly burned in electric utility boilers. In general, it appears black with banded layers of glossy and dull black. Typical bituminous coals have heating values of 10,500 to 14,000 Btu/lb (24,423 to 36,053 kJ/kg) and a fixed carbon content of 69 to 86%. The heating value is higher, but moisture and volatile content are lower than the subbituminous and lignite coals. Bituminous coals rarely experience spontaneous combustion in storage. Furthermore, the high heating value and fairly high volatile content enable bituminous coals to burn easily when pulverized to a fine powder. Some types of bituminous coal, when heated in the absence of air, soften and release volatiles to form the porous, hard, black product known as *coke*. Coke is used as fuel in blast furnaces to make iron.

Anthracite Anthracite, the highest rank of coal, is shiny black, hard and brittle, with little appearance of layers. It has the highest content of fixed carbon, 86 to 98%. However, its low volatile content makes it a slow burning fuel. Most anthracites have a very low moisture content of about 3%; heating values of 15,000 Btu/lb (34,890 kJ/kg) are slightly lower than the best quality bituminous coals.

APPENDIX E
PNM SJGS BART ANALYSIS (JUNE 2007)
EXCERPT FROM SECTION 4.1.4

SJGS fires a local New Mexico coal. The coal burned at SJGS has been referred to as both a subbituminous coal and a bituminous coal, since it possesses qualities that place it in a "gray area" between the bituminous and the subbituminous categories of coal. Based on these characteristics, the ASTM D388 classification would place the SJGS coal in either of the bituminous Group C or subbituminous Group A coal category. The difference between these two groups is not relevant, but the fact that the SJGS coal cannot be categorized as subbituminous Group C is very important in that subbituminous Group C includes PRB coals, which are known to produce very low NO_x emissions when fired in utility boilers. Table 1 compares the fuel fired at SJGS to typical bituminous and PRB fuels. This fundamental understanding of the variation in NO_x formation from different types of US coals explains why the expected NO_x rates of boilers burning the coal fired at SJGS cannot be as low as boilers firing PRB subbituminous coals.

The coal burned at SJGS is less volatile and has a lower oxygen and moisture content than PRB coals. The greater volatility and higher oxygen and moisture content found in PRB fuels are key to the lower NO_x emissions seen in boilers combusting PRB coal. The high volatility in PRB coals reduces combustion time. The higher fuel oxygen content reduces the amount of additional air (i.e., nitrogen) required for combustion; the higher fuel moisture content reduces the flame temperature and, therefore, reduces the formation of thermal NO_x. The nitrogen content in the fuel affects NO_x generation because of the oxidation of fuel-bound nitrogen. As it relates to the amount of NO_x generated from combustion, the coal burned at SJGS is more similar to the low-sulfur bituminous coal than it is to PRB subbituminous coal.

A comparison of the New Mexico subbituminous coal burned at SJGS to a typical subbituminous PRB (Bucksin, WY mine) and a typical low-sulfur bituminous coal (Twentymile, CO mine) is shown in Table 4-3.

Another factor affecting the potential for NO_x reduction at SJGS is the boiler design. Because of the HHV of the coal, the SJGS boilers are smaller in size (effective boiler volume) than similar output capacity boilers combusting PRB coal. This has a negative effect on potential NO_x emissions reduction because a smaller volume boiler will operate hotter, thus increasing thermal NO_x formation. Additionally, SJGS Units 1 and 2 have limited flame length because of the high heat input burners on the front wall of the boiler. This reduces the effectiveness of the overfire air from the OFA ports.

Table 1
Coal Properties Comparison

	Typical Subbituminous PRB	SJGS New Mexico Subbituminous	Typical Low-Sulfur Bituminous
Ultimate coal analysis, as received			
Carbon, %	49.00	54.52	64.05
Hydrogen, %	3.24	4.24	4.53
Sulfur, %	0.35	0.77	0.50
Nitrogen, %	0.63	1.08	1.63
Oxygen, %	11.68	9.38	10.09
Ash, %	5.15	21.29	9.80
Moisture, %	29.95	8.72	9.40
Total, %	100.00	100.00	100.00
Higher Heating Value, Btu/lb (as received)	8,400	9,692	11,400
Volatile matter, % (as received)	30.25	34.3	35.8
Volatile matter, % (dry)	43.18	37.6	39.5

Notes:

1. Typical subbituminous PRB analysis was based on Bucksin Mine (Wyoming).
2. Low-sulfur bituminous analysis was based on Twentymile Mine (Colorado).
3. SJGS New Mexico subbituminous analysis was based on BART analysis design basis.
4. SJGS New Mexico subbituminous volatile matter is referenced from SJGS consent decree Environmental Project Design Criteria, Sargent & Lundy, June 15, 2006.